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James Stoffer, PI.

George Daniel Waddill, Thomas O'Keefe, Richard Brow, Matt O'Keefe, coPIs

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University of Missouri-Rolla
Rolla, MO 65409

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Mr. Steven Szaruga Prime Contract F 33615-97-D-5009
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AFRL/MLBT
Wright Pat Airforce Base

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14. ABSTRACT

The University of Missouri-Rolla was able to purchase a Kratos XPS Spectroscopy System, from Kratos Analytical, Valley Center, CA, 92082, for $465,000. AFOSR supplied $183,000 and the University supplied $282,000. The system is operational and supports the AFOSR projects entitled "Development of Environmentally Safe Aircraft Coatings." We have been able to determine the ratio of Ce^{+3} / Ce^{+4} in the Cerium Conversion Coatings which is important in the development of these materials for use as a replacement of Chrome Conversion Coatings for Aircraft aluminum alloys. We have developed Cerium Conversion Coatings which pass 336 hours salt fog testing. We are working to develop a primer system that will pass 2000 hours salt fog testing.

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Final Report for ONR Grant No. F49620-00-1-0195

By
James Stoffer
University of Missouri-Rolla
Rolla, MO 65409

ABSTRACT

The University of Missouri-Rolla was able to purchase a Kratos XPS Spectroscopy System, from Kratos Analytical, Valley Center, CA, 92082, for $465,000. AFOSR supplied $183,000 and the University supplied $282,000. The system is operational and supports the AFOSR projects entitled "Development of Environmentally Safe Aircraft Coatings." We have been able to determine the ratio of Ce^{+3} / Ce^{+4} in the Cerium Conversion Coatings which is important in the development of these materials for use as a replacement of Chrome Conversion Coatings for Aircraft aluminum alloys. We have developed Cerium Conversion Coatings which pass 336 hours salt fog testing. We are working to develop a primer system that will pass 2000 hours salt fog testing.

REPORT

In an effort to develop a suitable replacement for chrome in aircraft coatings technology, a multi-faceted research program was initiated at University of Missouri-Rolla (UMR), in conjunction with the cooperative support of Boeing-St. Louis. This program is funded by the AFOSR Grants Nos: F49620-00-1-0195, F33615-97-D-5009 and F49620-96-1-0140. The focus of the program was on the use of cerium chemistry to provide the corrosion inhibition for aluminum alloys used in the aircraft industry. The primary tasks identified for this project were the development of (1) a non-chromated conversion coating and surface treatment and (2) a non-chromated primer coating system for military aircraft.

The principal program requirement was the development, characterization and evaluation of inorganic coatings that can serve as potential replacements for the chromate based corrosion preventative coatings presently in use. The following major accomplishments have been achieved: (1) the development of an electrolytic cerium conversion coating which has a 85 to 100% success rate in passing two week salt fog corrosion tests, (2) the design of a new dip (immersion) cerium coating which in some isolated tests a number of specimens have given good corrosion resistance in a 1 to 2 week time frame, and (3) a promising organic primer coating that incorporates cerium salts as inhibitors into the organic carrier to provide corrosion protection to the aluminum alloys.

The use of the XPS system was important in helping us to determine the ratio of Ce^{+3} / Ce^{+4} in the Cerium Conversion Coatings. An example of a spectrum is given in Figure 1. These are from samples that pass our 336 hour salt fog testing, a mil spec requirement for any new coating. An example of these conversion coatings is shown in Figure 2. The next task was to develop a primer system to go 2000 hours in sat fog testing. An example of one of these samples is shown in Figure 3.

In conclusion, the grant, which permitted the purchase of the KRATOS XPS system, was and is very helpful in our efforts to find a replacement for chrome in aircraft coatings.

Acknowledgment

In all publications, the authors express thanks for funding of this research from AFOSR Grant No. F33615-97-D-5009, AFOSR Grant No. F49620-00-1-0195, and NSF Grant DMR-9704288, The Boeing Company and the Missouri Department of Economic Development as appropriate.

Publications

The following are publications that used UMR's Krados XPS System:

1. **SRET evaluation of cerium conversion coatings.** Hayes, Scott; Stoffer, James O.; O'Keefe, Thomas J.; Schuman, Thomas P.; Patwardhan, Shantanu; Morris, Eric; Yu, Paul. Materials Research Center, University of Missouri-Rolla, Rolla, MO, USA. Polym. Mater. Sci. Eng. (2001), 85 140-141.

2. **Environmentally safe aircraft conversion coatings.** Stoffer, James O.; O'Keefe, Thomas J.; O'Keefe, Matthew; Hayes, Eric Morris Scott; Yu, Paul; Lio, Xuan. Materials Research Center, University of Missouri-Rolla, Rolla, MO, USA. Int. SAMPE Tech. Conf. (2002), XX, YYY and (2000), 32 879-888.

3. **Corrosion inhibition of intrinsically conductive polyaniline on cerium conversion coated aluminum alloy.** Stoffer, James O.; Pittman, Matt; O'Keefe, Thomas J.; Morris, Eric; Zhang, Zhiyi. University of Missouri-Rolla, Rolla, MO, USA. Polym. Mater. Sci. Eng. (2000), 83 317-318.

4. **Environmentally compliant aircraft coatings.** Stoffer, James O.; O'Keefe, Thomas J.; Morris, Eric; Hayes, Scott; Yu, Paul; Pittman, Matt. Materials Research Center, University of Missouri-Rolla, Rolla, MO, USA. Polym. Mater. Sci. Eng. (2000), 83 311-312.

5. **Cerium –based conversion coatings for aluminum alloys.** J. Stoffer, T. O'Keefe, M. O'Keefe, W. Fahrenholtz, T. Schuman, P. Yu, E. Morris, S. Hayes, A. Williams, A. Shahin, and B. Rivera, University of Missouri-Rolla Rolla, MO 65409, International Waterborne, High-Solids, and Powder Coatings Symposium, February 6-8, 2002, New Orleans, LA, USA

6. **Cerium-Based Corrosion Protection Systems for Aluminum Alloys.** E.L. Morris, J.O. Stoffer, T.J O'Keefe, M. O'Keefe, W. Fahrenholtz,T. Schuman, P. Yu, S. Hayes, A. Williams, B. Rivera and Chris Singelton, University of Missouri-Rolla, Rolla, MO 65409. 2002 Tri-Service Corrosion Conference, January 14-18,2002, San Antonio, TX and to be published in Int. SAMPE Tech. Conf. (2002), XX, YYY.

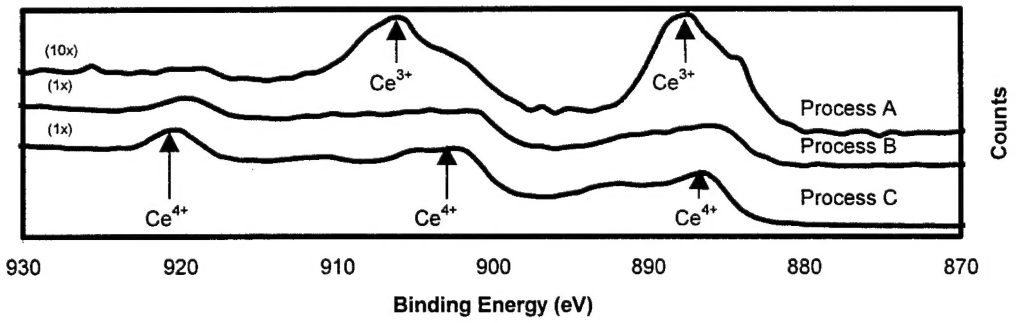


Figure 1. XPS of Cerium Conversion Coatings.

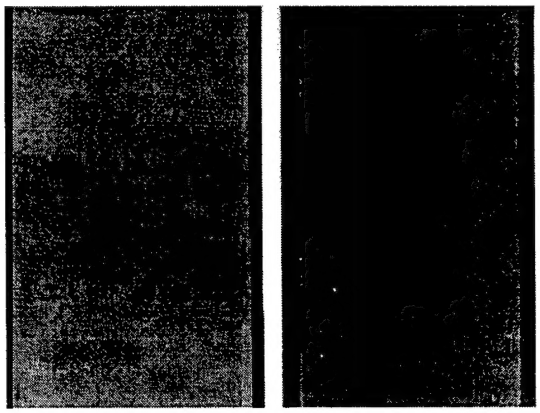
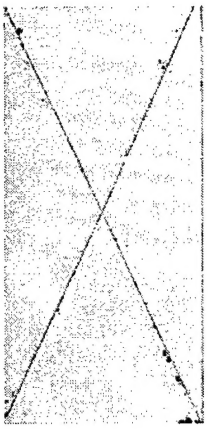
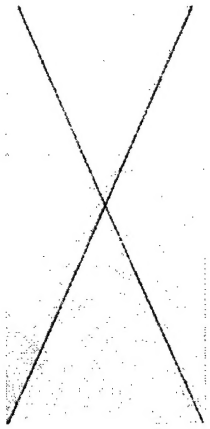


Figure 2. UMR Cerium Conversion Coating and Current Chrome Conversion Coating after 336 hrs in salt fog.

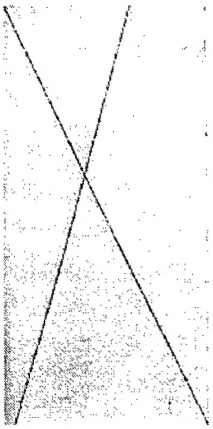


Bare Al 7075-T6
No Inhibitor

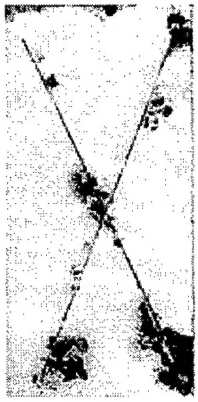
CrCC Al 7075-T6
No Inhibitor



CrCC Al 7075-T6
Primer + Inh. I

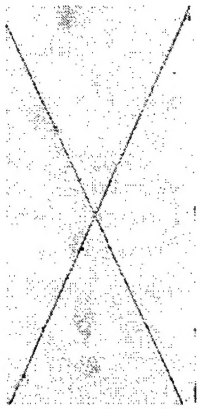


CeCC Al 7075-T6
Primer + Inh. I

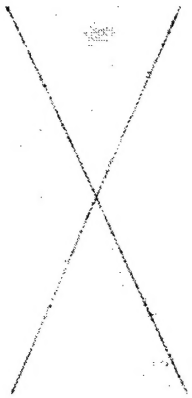


Bare Al 2024-T3
No Inhibitor

CrCC Al 2024-T3
No Inhibitor



CrCC Al 2024-T3
Primer + Inh. I



CeCC Al 2024-T3
Primer + Inh. I

Figure 3. Representative Al 7075 T-6 And Al 2024 T-3 Panels After 2000 Hours ASTM Salt Spray.